FTC Short Course Functional Data Analysis
October 2022

Course Materials Download Link: `https://github.com/pangdu3a/fda`

Course goals: Having successfully completed this course, students will be able to:

- identify data sets that are appropriate for functional data analysis,
- explore data with functional summary statistics,
- explain functional principal component analysis and apply it to functional data examples,
- apply functional regression models to investigation of the relationships between functional variables.

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Preferred Background Knowledge:

- Regression and Analysis of Variance:

  Principles and methods of data analysis employing linear models for both continuous response variables and categorical variables: general linear models and generalized linear models.

- Statistical Inference:

  Decision theoretic formulation of statistical inference, concept and methods of point and confidence set estimation, notion and theory of hypothesis testing, relation between confidence set estimation and hypothesis testing.

Recommended References:

- MAIN REFERENCE: *Functional Data Analysis*, by Ramsay & Silverman, (2nd ed., 2006), Springer, ISBN: 038740080X.
- *Applied Functional Data Analysis*, by Ramsay & Silverman, (2002), Springer, ISBN: 0387954147.
- *Functional Data Analysis with R and MATLAB*, by Ramsay, Hooker & Graves, (2009), Springer, ISBN: 0387981840.

- *Introduction to Functional Data Analysis*, by Kokoszka & Reimherr, (2017), Chapman and Hall/CRC, ISBN: 9781498746342.

Relevant Software:

- R `fda` package by Jim Ramsay (a Matlab version also available from Giles Hooker).
- Matlab PACE package by the UC Davis group led by Hans Müeller and Jane-Ling Wang.

Topics to be covered:
Chapter 1: Introduction to FDA
Chapter 2: Tools for exploring functional data
Chapter 3: From functional data to smooth functions
Chapter 5: Smoothing functional data with a roughness penalty
Chapters 8-10: Functional PCA
Chapters 13-16: Functional linear models

1. Introduction to functional data
2. Exploratory functional data analysis
   (a) Summary statistics for functional data
   (b) Phase plane plots of periodic effects*
3. Smoothing functional data
   (a) Smoothing by basis function systems
   (b) Smoothing by roughness penalties
4. Functional principal component analysis
   (a) Definition
   (b) Visualization
   (c) Computation
   (d) Bivariate and multivariate functional PCA
5. Functional regression models
   (a) Introduction
   (b) Functional response vs. multivariate predictor
   (c) Concurrent models
   (d) Scalar response vs. functional predictor
   (e) Functional response vs. functional predictor